Comparative Study of Forming Limit Diagram for AISI 1020

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Abstract— The use of sheet metal forming simulation has reduced lead time and costs for the development of new forming component significantly. The accuracy of the simulations is to a large extent dependent on the quality of the material properties provide as input to the simulations. Improving the quality of the material properties is the key factor in order to further increase the accuracy of the simulations. This study is focused on the forming limit properties of sheet metal. The purpose of the report is to investigate the possibility of replacing time consuming and costly experimental forming limit diagram (FLD) by theoretically predicted ones. Finally, Finite Element simulation of limit Height Test has been performed in order to investigate how well Finite Element necking predictions agree with the ones of the above theoretical models.

Key words: FLD, X – axis

I. INTRODUCTION

The FLD, originally developed by G.M. Goodwin and S.P. Keeler, allows forming severity to be obtained from the strains that occur during sheet metal forming. Measurement of the critical strains on many production and laboratory parts formed from 0.035" (0.89 mm) cold rolled steel resulted in the compilation of the original Keeler Goodwin diagram. Critical strains are those strain is measured after local thinning has started. The critical strain level for a given material is obtained by measuring the final major and minor ellipse diameters in the severely deformed region of the part and converting them into engineering strain. This major minor strain combination defines one point on the critical strain level curve of the FLD. FLD is a plot, which is used to check whether the stretched sheet is within its stretching limit, or not. Actually it is nothing but etching some circles on the sheet before forming and measuring the strains in the sheet. This is draw taking minor strain in X – axis and major strain in Y – axis.

II. LITERATURE SURVEY

1) Suresh Kurra, Srinivasa Prakash Regalla "Experimental and numerical studies on formability of extra-deep drawing steel in incremental sheet metal forming" Journal of Material Research and Technology. 2014; 3(2): 158–171.
2) Ravi J Bhatt, Mallika R Bhatt "FLD Creation for SS304 Using Experiments & It's Validation Using Hyper Form 11.0" HTC 2012.
3) Dr.Sc. Amra Talic – Cikmis, "Experimental determination of forming limit diagram" 14th International Research/Expert Conference Trends in the Development of Machinery and Associated Technology" TMT 2010.
4) P.H. Matin, L.M. Smith, and S. Petrusevski "A method for stress space forming limit diagram construction for aluminum alloys" Journal of Materials Processing Technology 174 (2006) 258–265.
5) M.C. Butuc, J.J. Gracio, A. Barata da Rocha "An experimental and theoretical analysis on the application of stress-based forming limit criterion" International Journal of Mechanical Sciences 48 (2006) 414–429.

III. MATERIAL PROPERTY

Material 1020 steel responds well to cold work and heat treating. Weld ability is fair.

A. Applications:

Shafts, lightly stressed gears, hard wearing surfaces, pins, chains and case hardened parts where core strength is not critical. 1020 is suitable for case hardened parts where core strength is not critical.

Physical Properties	Metric	English
Density	7.87 g/cc	0.284 lb/in^3

Table 1: Physical Properties of AISI 1020

Mechanical Properties	Metric	English
Ultimate Tensile Strength	420 MPa	60900 psi
Yield Tensile Strength	350 MPa	50800 psi
Elongation at break	15 %	15 %
Modulus of Elasticity	205 GPa	29700 ksi
Bulk Modulus	140 GPa	20300 ksi
Poisson Ratio	0.29	0.29
Machinability	65%	65%
	Based on AISI 1212 as 100% machinability	

Table 2: Mechanical Properties of AISI 1020

Component Element Property	Metric	English
Carbon, C	0.17-0.23%	0.17-0.23%
Iron, Fe	99.08-99.53	99.08-99.53
Manganese, Mn	0.30-0.60%	0.30-0.60%
Phosphorous, P	<=0.040%	<=0.040%
Sulfur, S	<=0.050%	<=0.050%

Table 3: Component Element Properties of AISI 1020

IV. EXPERIMENTAL SETUP

The cupping test is developed to simulate more effectively the fracture conditions (Plane strain) found in most stampings. In this test a 20 mm diameter punch is used and sheet metal strips of varying width are clamped rigidly in a

blank holder and then stretched over the punch. The metal strips are marked with a grid of small circles (2.5 mm diameter) and the width strain at the fracture site is measured from the circle closest to the fracture. This width strain is minimum (close to plane strain) at some critical blank width of the sheet metal.

As the cupping test is able to simulate the most critical strain observed in stamping, it is the most popular test used in industry.

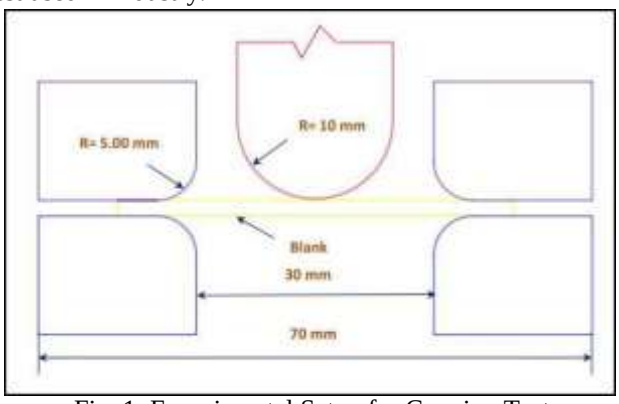

Fig. 1: Experimental Setup for Cupping Test

V. EXPERIMENTAL WORK

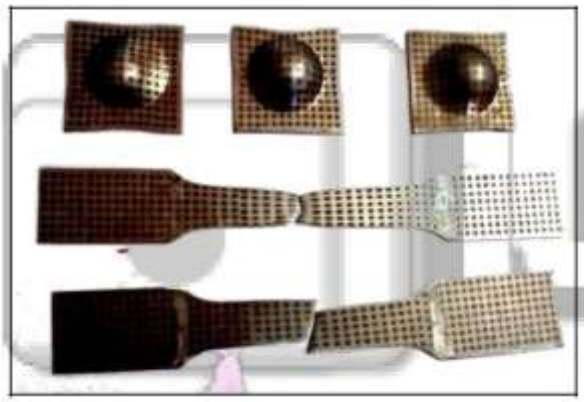

Fig. 2: Tensile Test and Cupping Test Of AISI 1020 Material

A. Experimental Result:

Uni-Axial test (Tensile Test)				
Sr. No.	Major Dia.	Minor Dia.	Major Strain	Minor Stain
1	3.84	2.31	0.42	-0.07
2	4.33	2.23	0.54	-0.11
3	3.78	2.33	0.41	-0.07
4	4.39	2.26	0.56	-0.10
5	4.43	2.20	0.54	-0.12
6	3.91	2.29	0.44	-0.08
7	4.33	2.10	0.54	-0.17
8	3.94	2.39	0.45	-0.04
9	3.91	2.39	0.44	-0.04
10	4.33	2.20	0.54	-0.12

Table 4: Test Result of Tensile Test

Bi-Axial test (Cupping test)				
Sr. No.	Major Dia.	Minor Dia.	Major Strain	Minor Stain
1	3.30	3.13	0.27	0.22
2	3.33	2.26	0.28	-0.10
3	2.94	2.00	0.16	-0.22
4	3.21	2.05	0.24	-0.19
5	2.88	2.10	0.14	-0.17
6	3.10	3.00	0.21	0.18
7	3.10	3.04	0.21	0.19
8	3.36	2.97	0.29	0.17
9	3.00	1.68	0.18	-0.39
10	2.75	2.71	0.09	0.08

Table 5: Test Result of Cupping Test

VI. HYPER FORM SIMULATION

Altair Hyper Form is a unique finite element based sheet metal forming simulation software solution. Hyper Form combines an extremely fast one step solver and incremental forming solution with the customized geometry manipulation and mesh generation capabilities of Hyper Mesh. Hyper Form provides engineers, at any stage of product design, with quick, valuable, and reliable information, reducing the overall product cycle

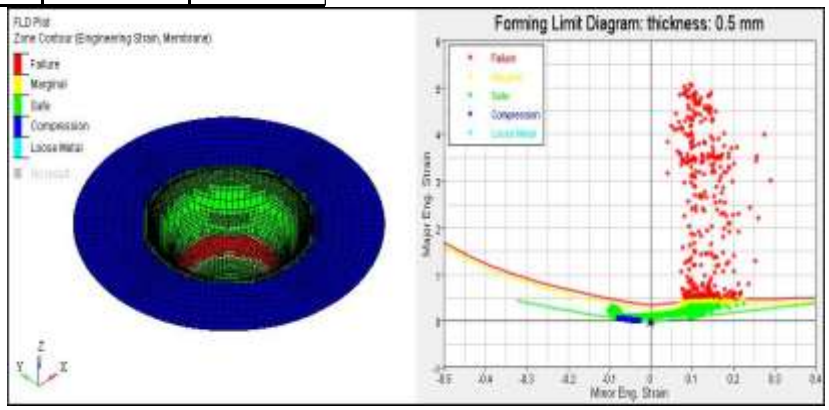

Fig. 3: Forming Limit Diagram of 0.5 Mm Thick Sheet

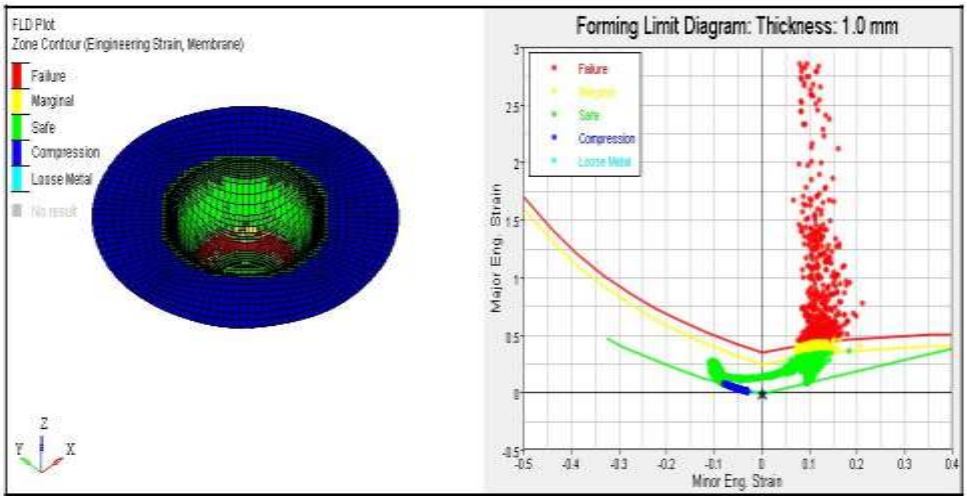

Fig. 4: Forming Limit Diagram of 1.0 Mm Thick Sheet

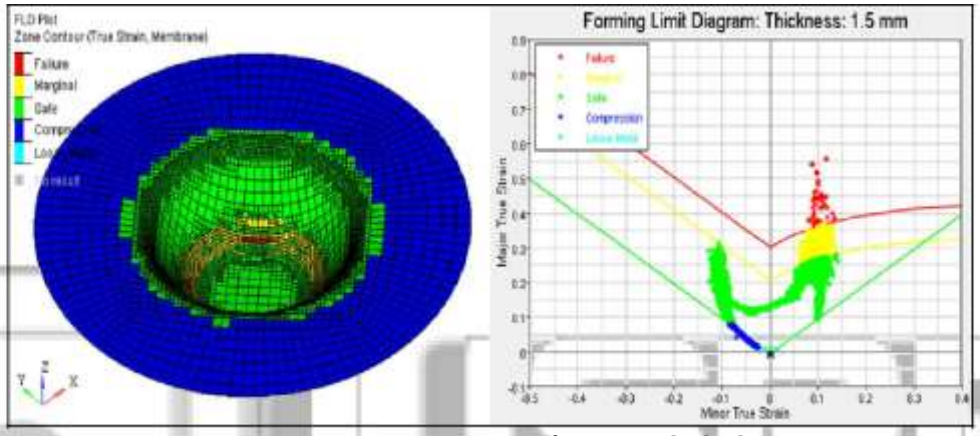

Fig. 5: Forming Limit Diagram of 1.5 Mm Thick Sheet

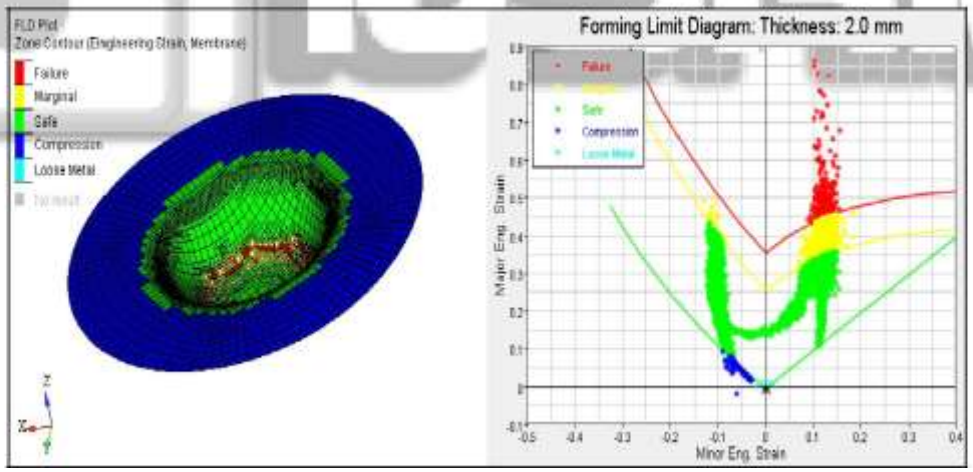

Fig. 6: Forming Limit Diagram of 2.0 Mm Thick Sheet

VII. Conclusion

1) For the FLD diagram cupping test is gives major strain value and minor strain value.
2) The simulative analysis reduces the cost and material for analysis.
3) The FLD generated by simulative analysis in HYPERFORM gives data for uni-axial strain, Plain strain and Bi- axial strain.
4) The strain is gradually reduced in 0.5mm, 1.0mm, and 1.5 mm thickens blank and the increasing in 2.0 mm blank in simulative result.

Reference

[1] Suresh Kurra, Srinivasa Prakash Regalla "Experimental and numerical studies on formability of extra-deep drawing steel in incremental sheet metal forming" Journal of Material Research and Technology. 2014 ; 3(2) : 158–171.

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